PETROLOGY OF AMOEBOID OLIVINE AGGREGATES IN ANTARCTIC CR CHONDRITES: COMPARISON WITH OTHER CARBONACEOUS CHONDRITES.
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Introduction:

Amoeboid olivine aggregates (AOAs) are important refractory components of carbonaceous chondrites and have been interpreted to represent solar nebular condensates that experienced high-temperature annealing, but largely escaped melting [e.g., 1,2]. In addition, because AOAs in primitive chondrites are composed of fine-grained minerals (forsterite, anorthite, spinel) that are easily modified during post crystallization alteration, the mineralogy of AOAs can be used as a sensitive indicator of metamorphic or alteration processes.

AOAs in CR chondrites are particularly important because they show little evidence for secondary alteration [3,4]. In addition, some CR AOAs contain Mn-enriched forsterite (aka low-iron, Mn-enriched or LIME olivine), which is an indicator of nebular formation conditions [4]. Here we report preliminary results of the mineralogy and petrology of AOAs in Antarctic CR chondrites, and compare them to those in other carbonaceous chondrites.

Methods:

Polished thin sections of Antarctic CR chondrites Y-881828, Y-791498, and A-881595 were examined in this study. Imaging, mineral identification and EDS analyses were performed using a JEOL JSM-7100F FE-SEM at National Institute of Polar Research (NIPR). Chemical analyses and X-ray maps were obtained using a JEOL JX-8200 EMPA at NIPR. A-881595 was originally classified as a CR chondrite [5], but reclassification as an ungrouped C3 has been suggested [6,7]. Nonetheless, we include A-881595 in this study. We also compare these samples with the CO chondrite Y-81020 (CO3.05), which is one of the most primitive carbonaceous chondrites [8], and reduced CV chondrite Efremovka and oxidized CV chondrite Allende (CV 3.1-3.4 and CV>3.6, respectively [9]).

Results and Discussion:

Petrology of AOAs in Antarctic CR chondrites

AOAs in CR chondrites in this study are less abundant than in CV and CO chondrites; only a few AOAs are identified in each thin section. AOAs in the CR chondrites are composed of forsterite, Al-diopside, anorthite, spinel, Fe,Ni-metal and FeS (Fig. 1a-d). As described in previous studies [4], the CR AOAs do not contain secondary nepheline or fayalitic olivine. In A-881595, some anorthite is replaced by Mg,Al-silicates (Fig.1e,f), that are similar to phyllosilicates in AOAs in aqueously altered chondrites such as Kaba [2] and Murchison [1]. Except for some AOAs in A-881595, AOAs in CR chondrites are texturally similar to those in the primitive carbonaceous chondrite Y-81020.

Matrix mineralogy

Matrices of CR chondrites are composed of fine-grained phases such as amorphous silicates, framboidal and plaquette magnetite, sulfides, calcite and phyllosilicates [3,10]. The abundance of magnetite varies among the CR chondrites, and lath-shaped phyllosilicates (<3 μm) are present in A-881595.

The matrix olivine grains of the CO and CV chondrites examined in this study show a general correlation between grain size and porosity vs. metamorphic subtype (Fig. 2;[2]). Also, the formation of fayalitic olivine appears to have resulted from aqueous alteration. For the CR chondrites, matrix textures show little porosity, similar to weakly metamorphosed CVs and COs (Fig. 2). The presence of lath-shaped phyllosilicates in A-881595 (Fig.2c) may indicate significantaqueous alteration of this sample.

Olivine compositions

Histograms of olivine compositions in CR chondrites Y-791498, A-881828, A-881595 together with those in Y-81020, Efremovka, and Allende are shown in Fig. 3. Olivines in AOAs from CR chondrites are nearly pure forsterite (Fo_{100-98}). Although it should be noted that the number of analysed points are smaller than in COs and CVs, CR AOAs show much smaller compositional ranges than the reduced CV chondrite Efremovka (Fo_{99-92}) and Allende AOAs (Fo_{97-59}). This observation is consistent with the previous studies that FeO enrichment of olivine is introduced by secondary alteration [e.g., 11]. In Allende, individual grains are typically zoned, with magnesian cores and ferroan rims, and ferroan olivine occurs in thick zones on the outside margins of Allende AOAs [2]. These characteristics are not observed in CR AOAs.

MnO/FeO ratios in AOA olivine in carbonaceous chondrites reflect nebular condensation conditions[e.g., 2, 12]. In this study, slight enrichment in Mn toward the rim of some CR AOAs is observed in elemental

maps, whereas no FeO enrichment is found, suggesting that these AOAs grew while nebular temperature was decreasing [2,4,12].

Chemical compositions of olivine in AOAs in CR chondrites are shown in Fig. 4. Many olivine grains have compositions close to MnO/FeO=1.0 (LIME). There is no obvious difference in olivine composition among Y-791498, Y-881828, and A-881595. Mn-rich, Fe-poor compositions are similar to AOAs in the primitive CO chondrite Y-81020, and different from Efremovka and Allende. As suggested by previous studies [e.g., 4], olivine in CR AOAs preserve the nebular conditions that are consistent with equilibration with nebular vapor in the stability field of olivine, without re-equilibration at lower temperatures [2,12]. Although secondary alteration of anorthite is observed in A-881595, AOA olivines seem to preserve their primary compositions.

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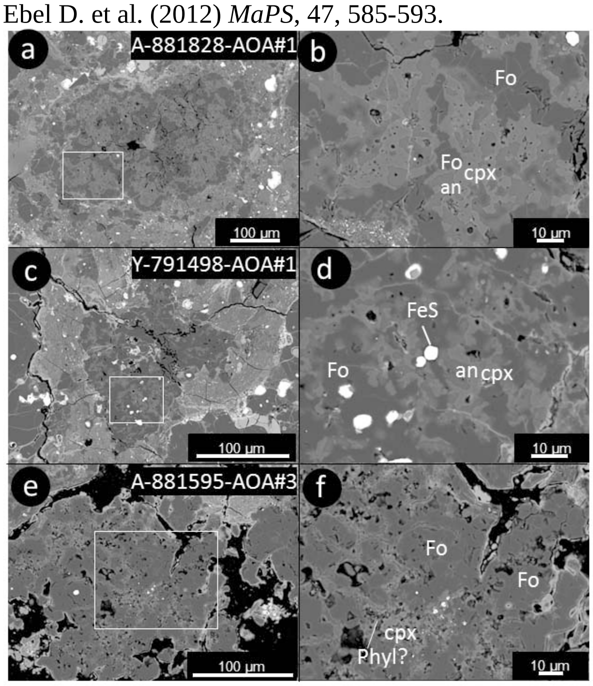

Fig. 1. BSE images of AOAs from CR chondrites. (a,b) A-881828 (c,d) Y-791498 (e,f) A-881595.

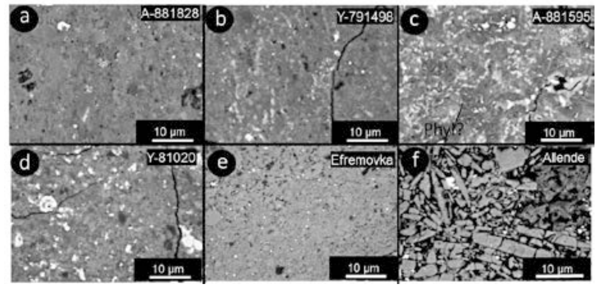

Fig.2. BSE images of matrix of CR chondrites (a-c), Y-81020 primitive CO (d), and CV chondrites (e,f).

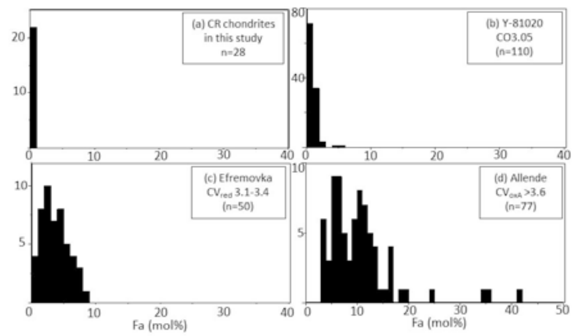

Fig.3. Histograms of olivine compositions in AOAs from CR chondrites Y-791498, A-881828, A-881595 (a), primitive CO chondrite Y-81020 (b), reduced CV chondrite Efremovka (c), and oxidized CV chondrite Allende (d). Olivines in CR chondrites are forsteritic, and show much smaller compositional ranges than those from the CV chondrites (c,d). The horizontal scale is Fa_0 to Fa_{40} for (a-c), Fa_0 to Fa_{50} for (d).

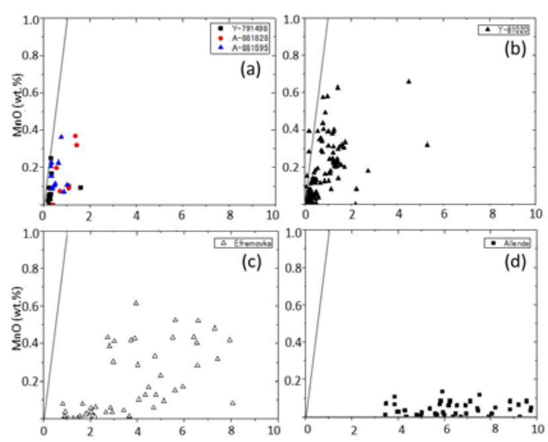

Fig. 4. Plot of FeO versus MnO for olivine from AOAs in this study. (a) CR chondrites, (b)Y-81020, (c) Efremovka, and (d) Allende. Analyses with >10 wt.% FeO are not plotted. Solid lines indicate constant wt.% ratio of MnO/FeO = 1.0.